The NAO and stratosphere-troposphere interaction

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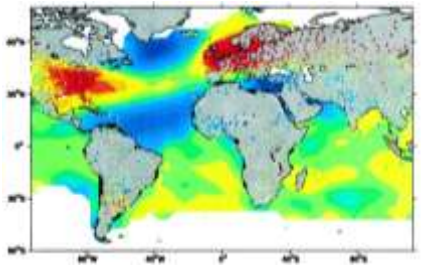
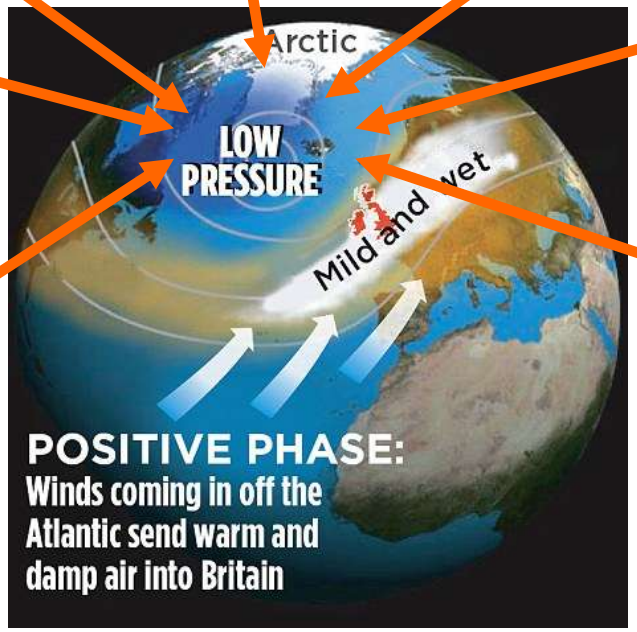
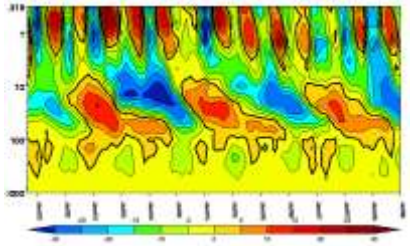
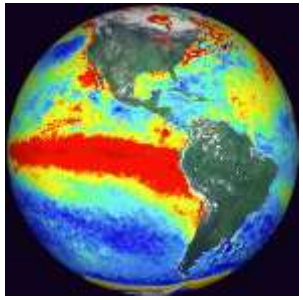
Several factors trigger variability in Atlantic winter climate

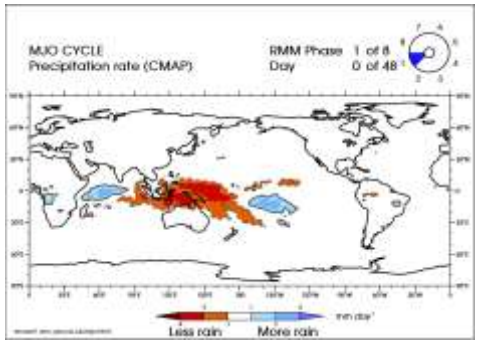
(A number of which are stratosphere related)



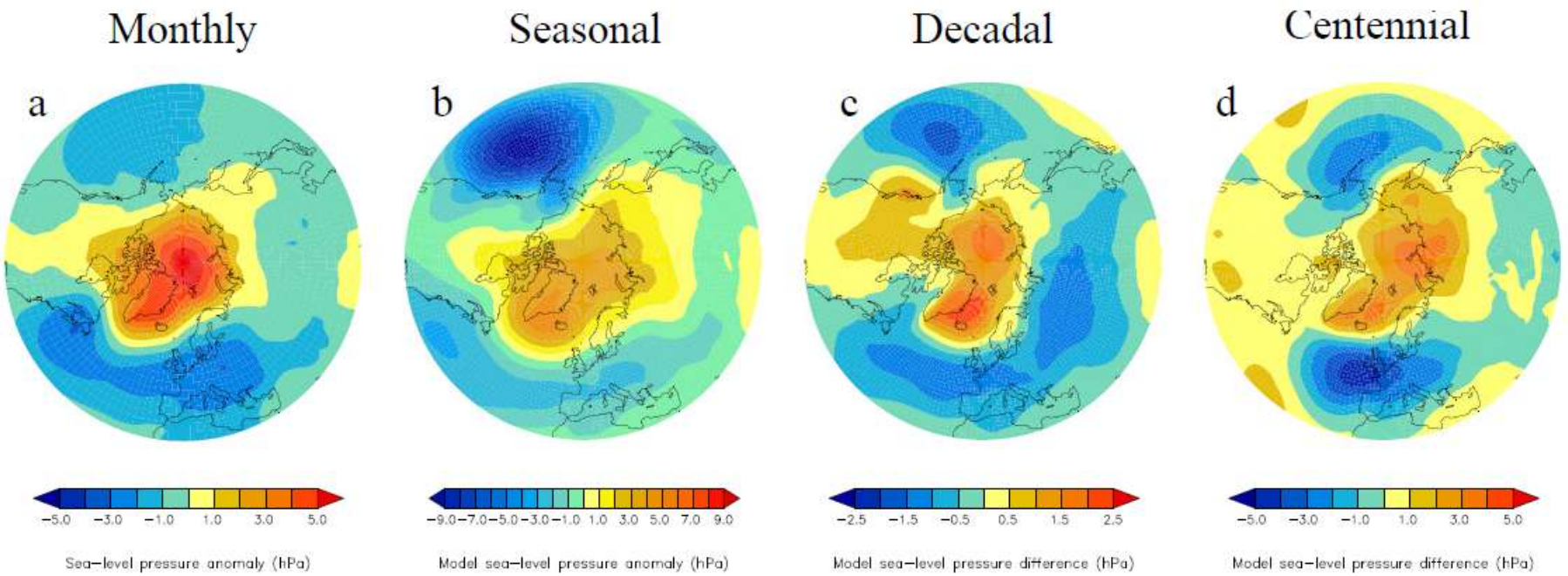








Stratospheric changes give the same response across timescales



SSW **ENSO** **Solar** **Climate Change**

All stratospheric – all show same response in troposphere

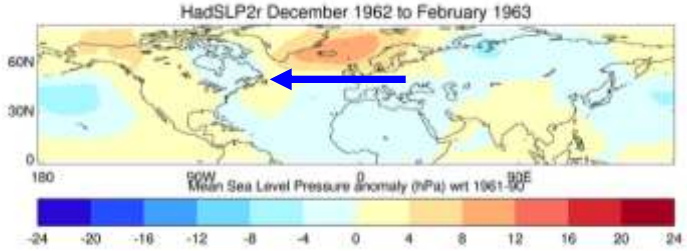
A similar response occurs in the southern hemisphere

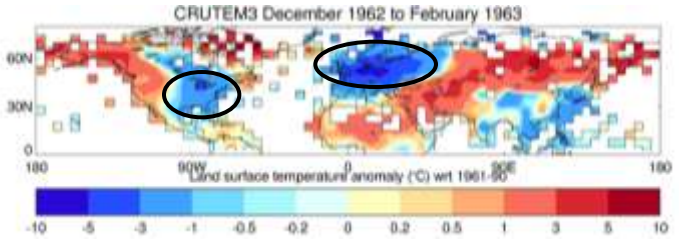
Kidston et al, accepted.

Characteristic pattern in surface climate

North Atlantic Oscillation or Arctic Oscillation

Winter 1962/63



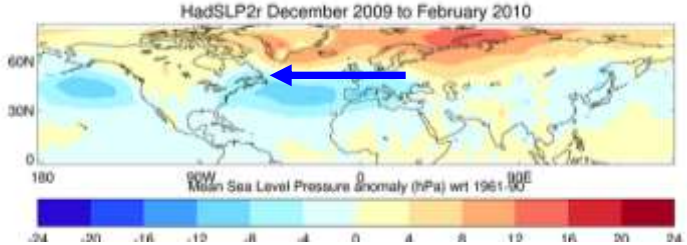


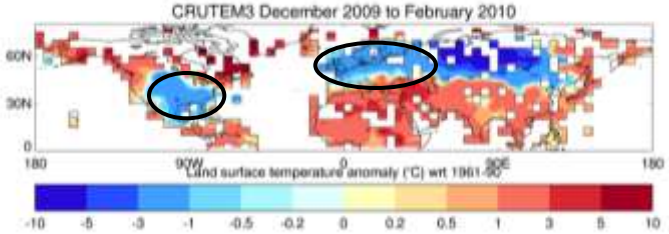
Weak P Gradient

Cold advection into Europe

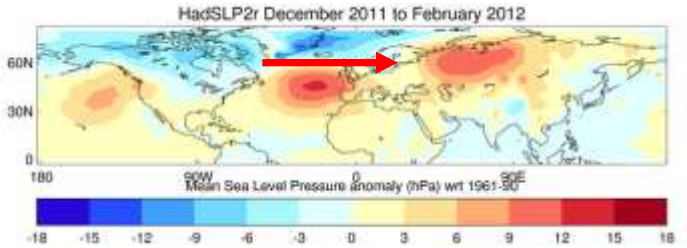
Cold, calm and dry

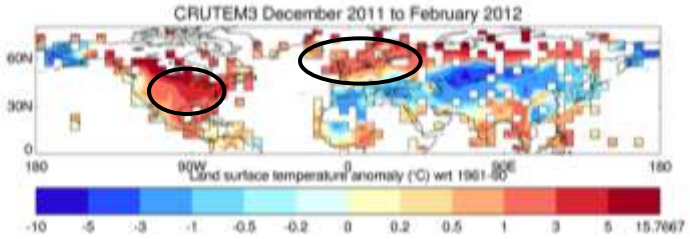
Winter 2009/10





Winter 2011/12



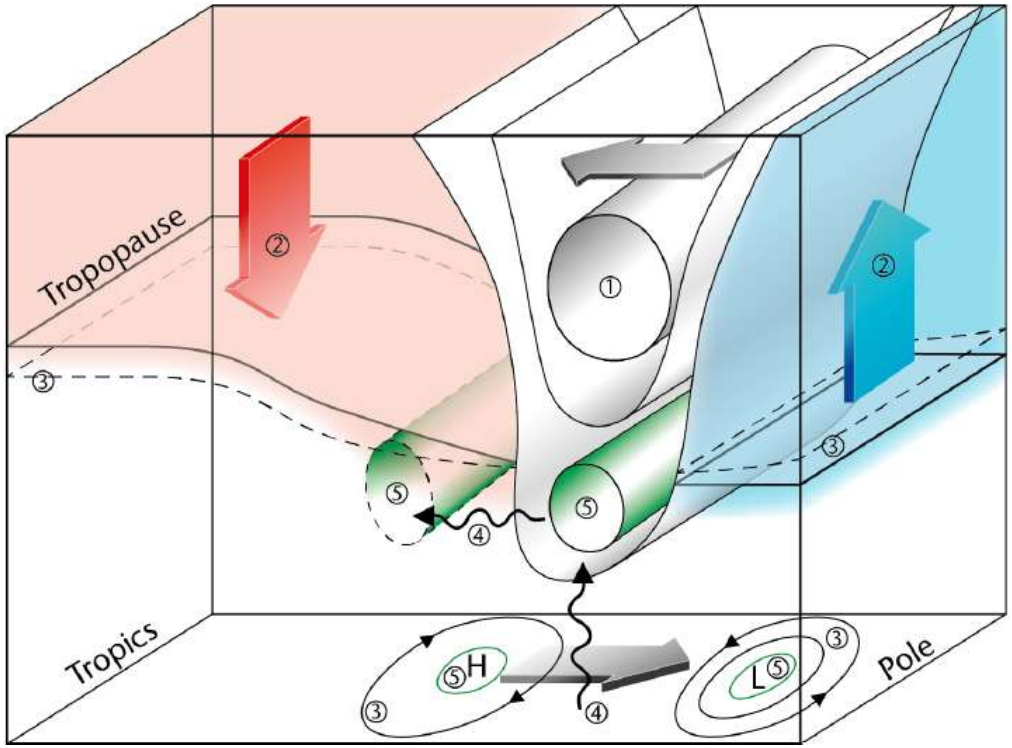


Strong P Gradient

Warm advection into Europe

Mild, wet and stormy c.f. 2013/14

Mechanisms



1) Reduction in wave driving => acceleration of jet

2,3) weaker Brewer-Dobson circulation, cooling of polar region

4,5) increased upper tropospheric wind and more/stronger tropospheric eddies

3,5) positive annular mode signal

Kidston et al, accepted.

Met Office GloSea5

Global Seasonal Forecast System 5

Model: **HadGEM3H N216L85O(0.25)**

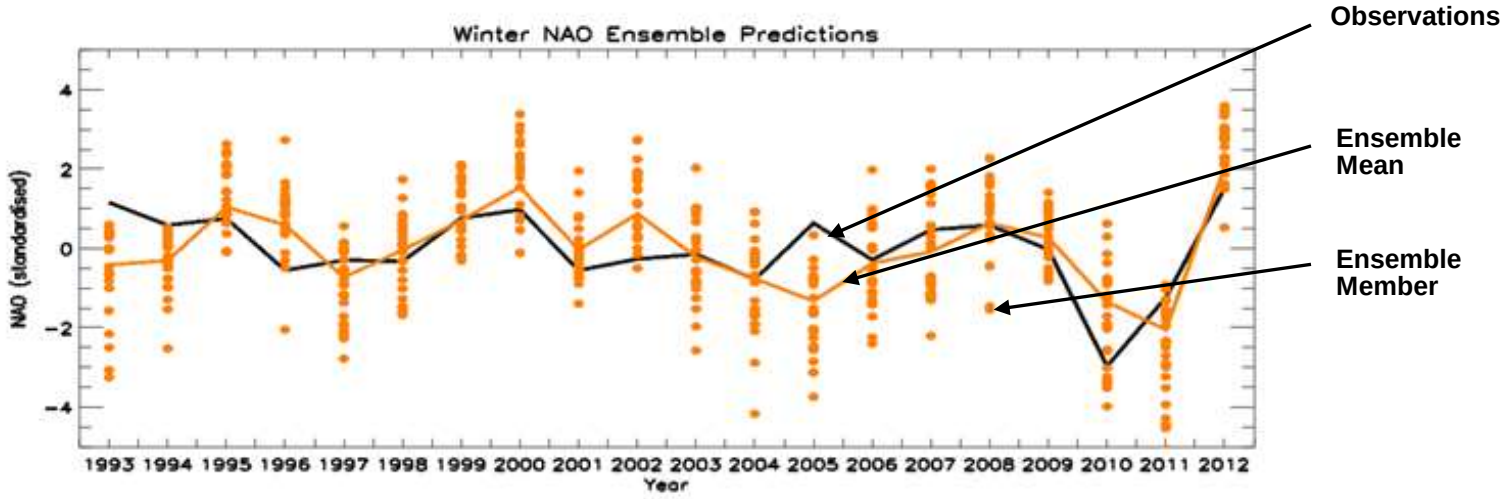
Initialisation: **NWP state + NEMOVAR + Sea Ice**

Winter Hindcasts: **ensemble forecasts starting around 1st August**

Predictability of the northern hemisphere

Skilful predictions of the winter NAO

+NAO
Mild, wet and stormy



-NAO
Cold, snowy and still

Winter NAO skill: correlation=0.62

Significant at the 98% level

Similar result holds for AO

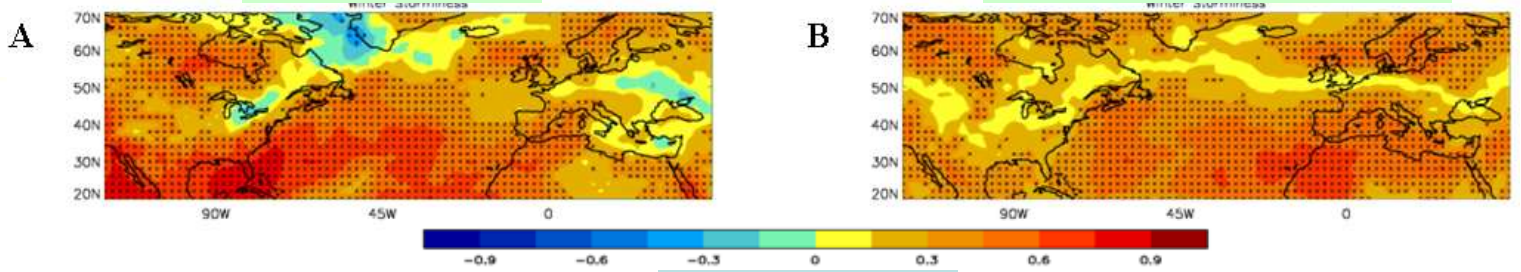
Scaife et al 2014, MacLachlan et al 2014, Athanasiadis et al 2014

Surface weather skill

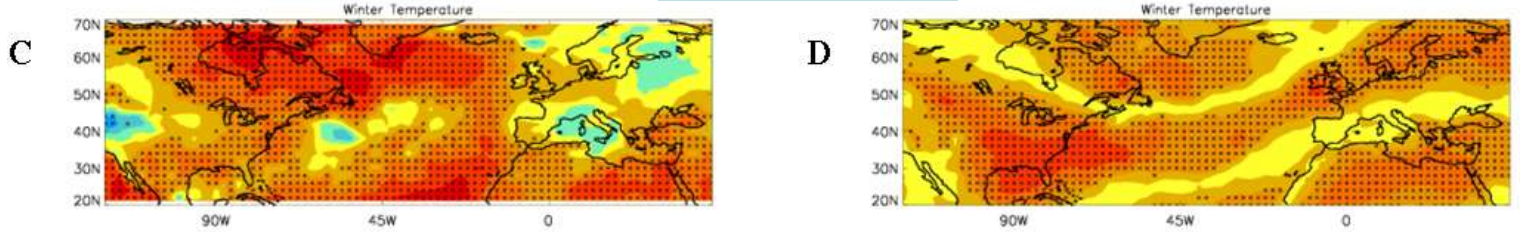
Raw model

storminess

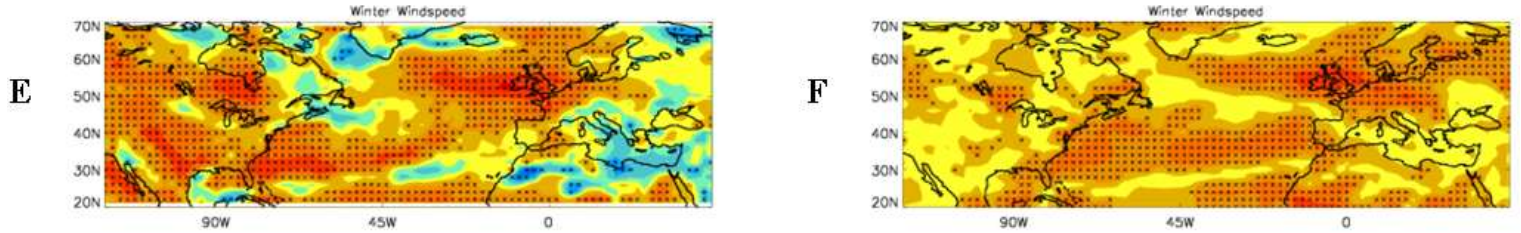
From NAO forecast



temperature



windspeed



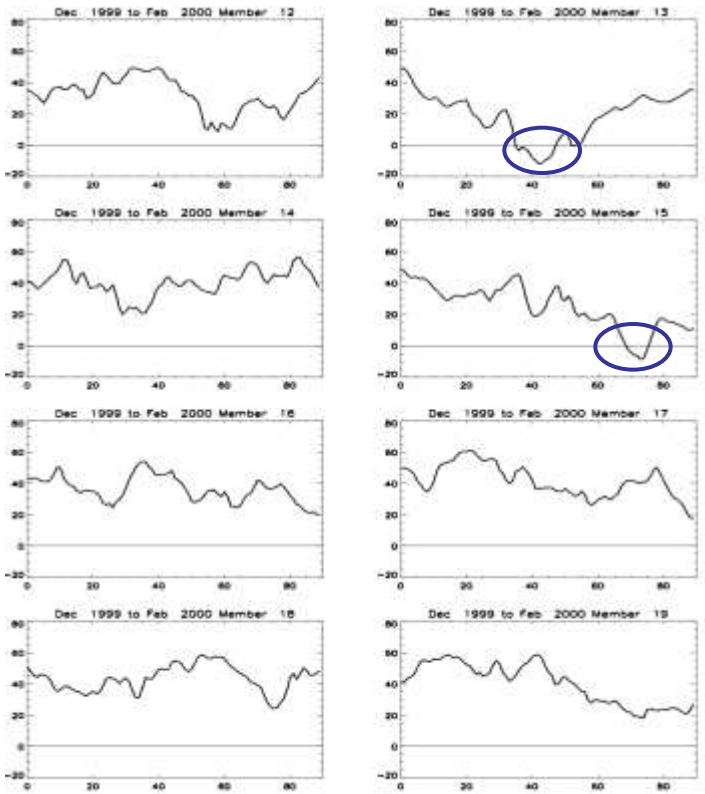
Skill for predicting impacts: storms, temperatures, winds…

Higher skill over Europe if inferred from forecast NAO only!

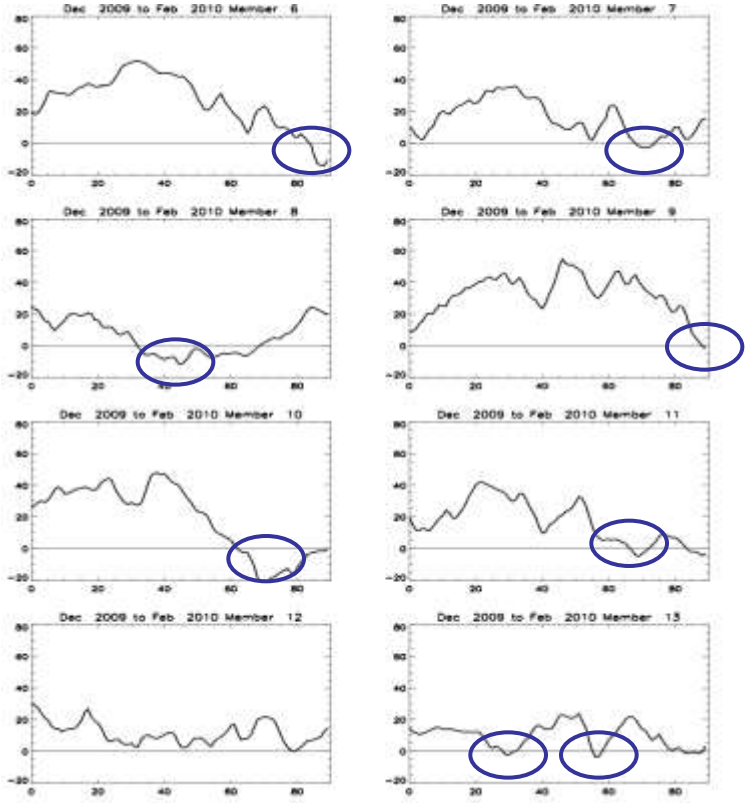
Scaife et al, GRL, 2014

Single predictions of stratospheric winds

Winter 1999/2000 +NAO



Winter 2009/2010 -NAO



Winter 1999/2000 has few SSW events

Winter 2009/10 has many

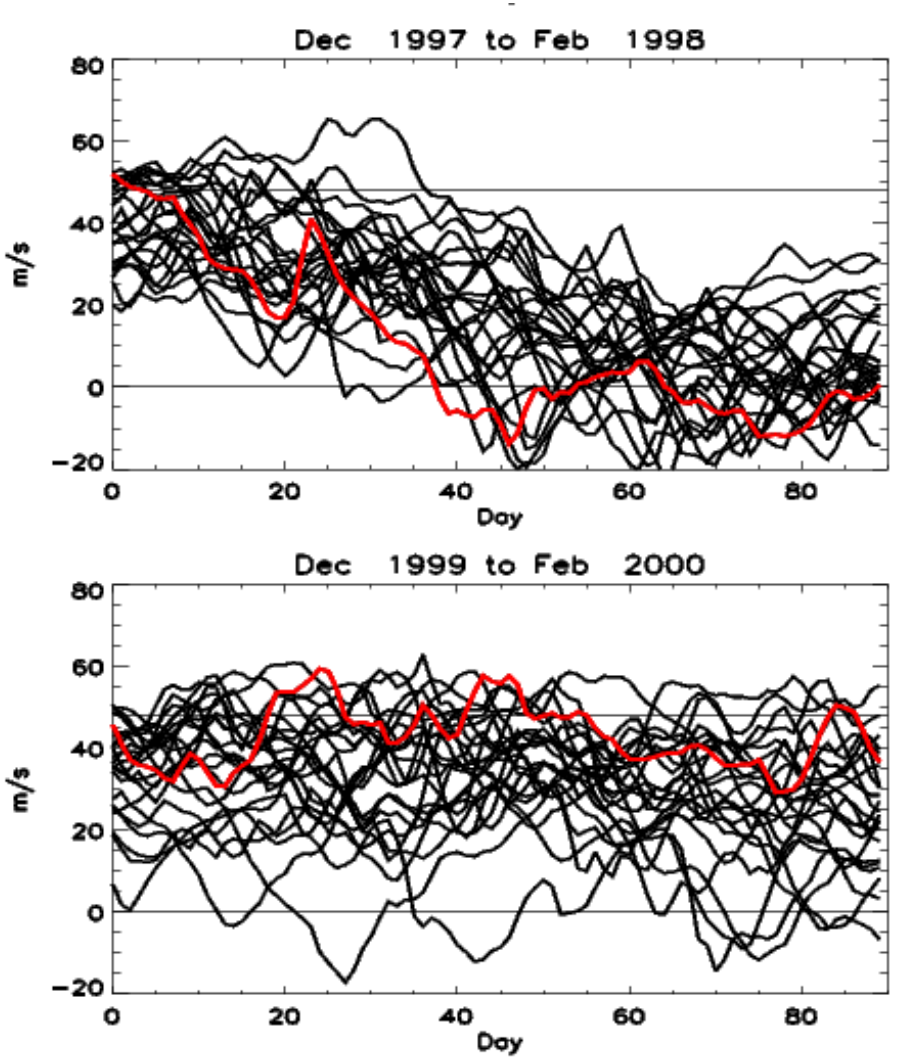
SSW events appear to have been more *likely* in 2009/10

Ensemble predictions of stratospheric winds
(10hPa, 60N)

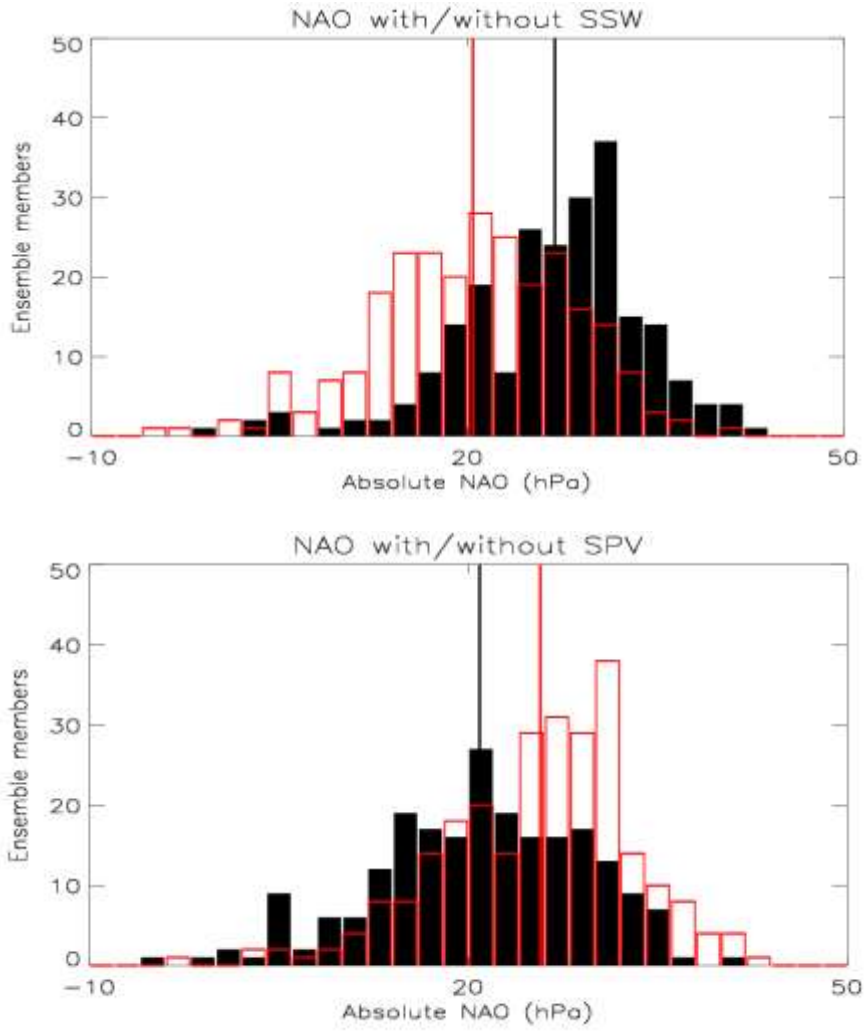
Ensembles of forecasts for each winter

Some winters show a large shift in probability of a SSW

=> Predictability



Predicted NAO is related to predicted probability of stratospheric events



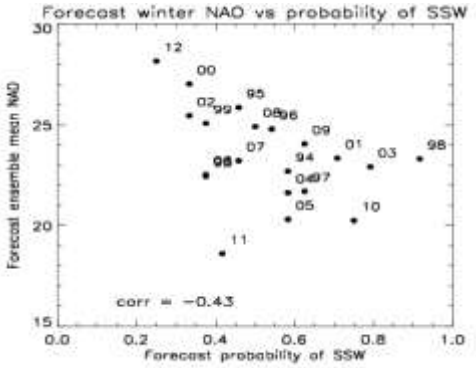
The distribution of NAO values is related to the occurrence or absence of stratospheric events

Top with/without SSW

Bottom with/without SPV

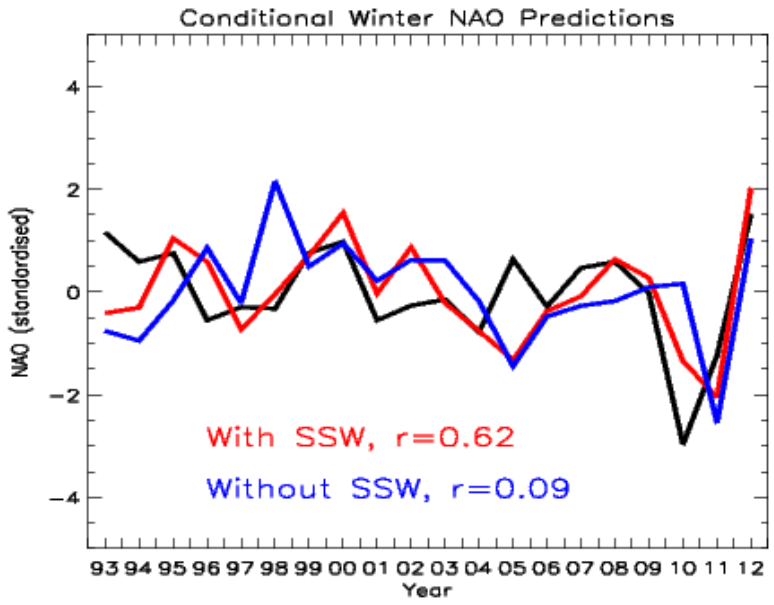
Average difference is ~6hPa

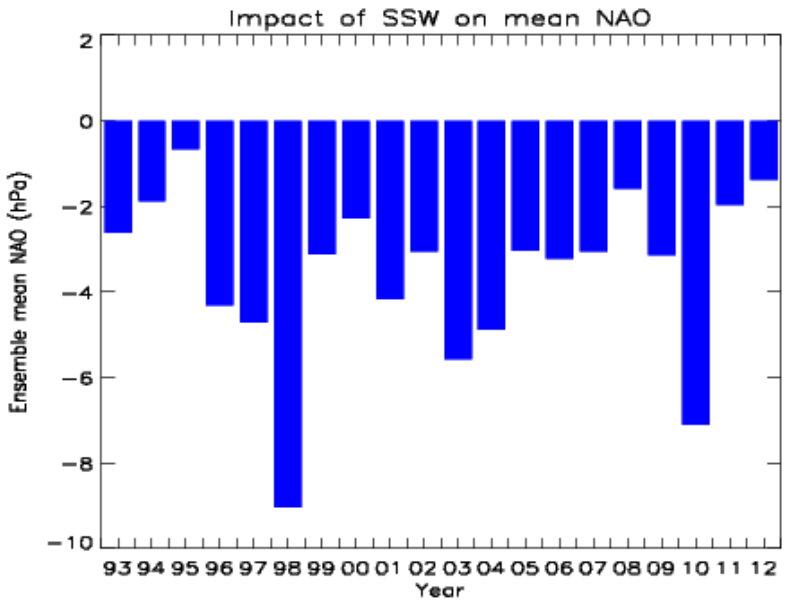
NAO is correlated with probability of SSW



Scaife et al, submitted

Predictability of the NAO vanishes without stratospheric events





Stratosphere is intimately involved in winter seasonal skill

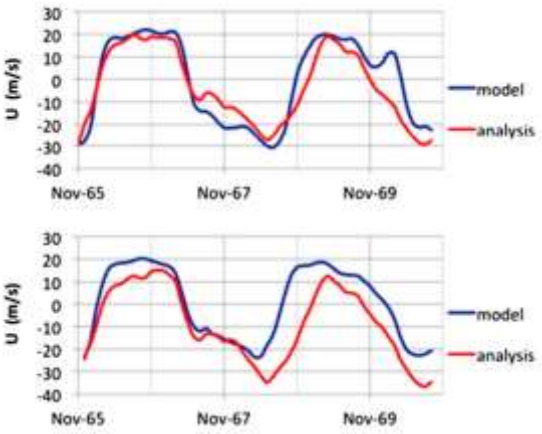
Not necessarily driving or causing the predictability though

Scaife et al, submitted

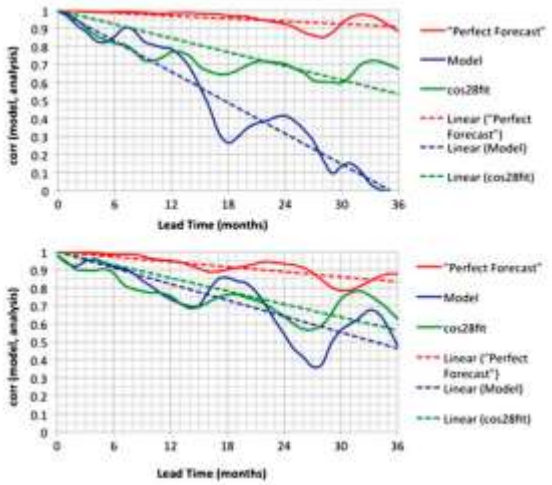
Unresolved question: effects of the QBO

(c.f. Ebdon 1975)

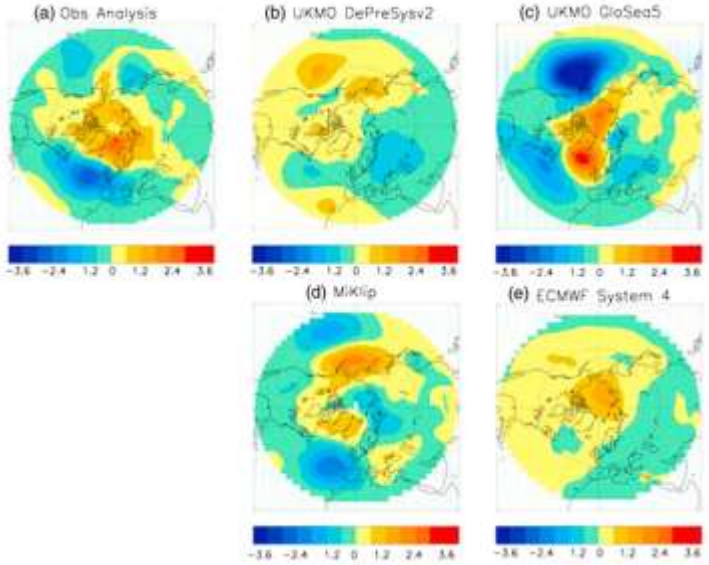
Simulation



Prediction



Teleconnection



Well simulated in some models

Regular and predictable out to a few *years* ahead

but

Surface signal is not well modelled in all systems

Scaife et al, GRL, 2014.

Summary

Same response across timescales

The stratosphere rings the NAO ‘bell’

Predictability on seasonal timescales for NAO/AO/SAM

Stratosphere *intimately involved* in forecast skill

Skill in NAO vanishes without stratospheric events

Some aspects unresolved:

- **teleconnections to QBO**
- **feedback from oceans**
- **relative importance of different coupling mechanisms**